The Relativistic Heavy Ion Collider

BNL/PHENIX Group

David Morrison

DOE NP RHIC Science & Technology Review
23 – 25 August 2016

BROOKHAVEN NATIONAL LABORATORY
a passion for discovery

Office of Science
U.S. DEPARTMENT OF ENERGY

Group composition and responsibilities

- Primary responsibility is operation of PHENIX experiment, hosting of activities – e.g, visitor support, computing, meetings, publication support – and research activity to optimize scientific output of the collaboration.
- Model of strong research involvement with PHENIX has been very successful – areas of particular expertise (e.g., neutral pions, photons, global observables, fluctuations), and ability to attract capable scientists
- Group leader (Morrison), two deputies (Steinberg, Woody) – work in conjunction with leaders of specific activities to coordinate and direct effort of group
- Current PHENIX activities include technical crew working on PHENIX R&R
- Activities directed toward anticipated sPHENIX project
  - detector prototypes and test beam activities
  - sPHENIX project management
- ATLAS HI physics analysis & ZDC project lead
- R&D (LDRD, PD, PECASE, TSAs (tech. service agreements), EIC R&D)

Sasha Bazilevsky (25%)

PHENIX

D. Morrison, GL
P. Steinberg, DL
C. Woody, DL
M. Faulkner, GA
B. Azmoun
J. Biggs
S. Boose
M. Chiu
G. David
E. Desmond
A. Franz
P. Giannotti
J. Haggerty
J. Huang
E. Kistenev
J. La Bounty
W. Lenz
M. Lenz
D. Lynch
E. Mannel
J. Mills
R. Nouicer
E. O'Brien
C. Pinkenburg
R. Pisani
S. Polizzo
C. Pontieri
M. Purschke
T. Sakaguchi
I. Sourikova
S. Stoll
Y. Suenaga
A. Sukhanov
M. Tannenbaum
F. Toldo
J. Tradeski

PHENIX

PHENIX Scientific Collaboration Yasuyuki Akiba — Spokesperson
Julia Velkovska — Deputy Spokesperson
Stephan Bathe — Deputy Spokesperson
Sasha Bazilevsky — Deputy Spokesperson

Jamie Nagle, Dave Morrison co-spokespersons through 2015

Publication support: Brant Johnson (RIF July 2016; contract for 20% FTE)

Web support: Hyon-Joo Kehayias (voluntary RIF December 2015)

Executive Council
Christine Aidala
Tom Hemmick
Itaru Nakagawa
Megan Connors
Marzia Rosati
Ralf Seidl
Jin Huang (appointed)
Joel Osborn (appointed)
Jamie Nagle (appointed)
Bill Zajc (appointed)
Yasuyuki Akiba (ex officio)
Julia Velkovska (ex officio)
Stephan Bathe (ex officio)
Sasha Bazilevsky (ex officio)
Mickey Chiu (ex officio)

Analysis Coordinator
Stephan Bathe

Computing Coordinator
Chris Pinkenburg
G4 Simulation Coordinator
Chris Pinkenburg
G3 Simulation Coordinator
Hubert van Hecke
VTX Software Coordinator
Takashi Hachiya

Physics Working Groups

HHJ
Nathan Grau
Marzia Rosati
Hubert van Hecke

PLHF
Takao Sakaguchi
Axel Drees
Maya Shimomura

Spin
Sanghwa Park
Ralf Seidl

Topical Groups
Gabor David (RIF July 2016) — γ and neutrals
Craig Ogilvie — jets
Cesar da Silva — quarkonia
Matt Durham — HF electrons
Sasha Lebedev — VTX
Mickey Chiu — MPC
Ermias Atomssa – HBD
Shengli Huang/Aneta Iordanova — Cu+Au
$W \leftarrow e$ working group
$W \leftarrow \mu$ working group

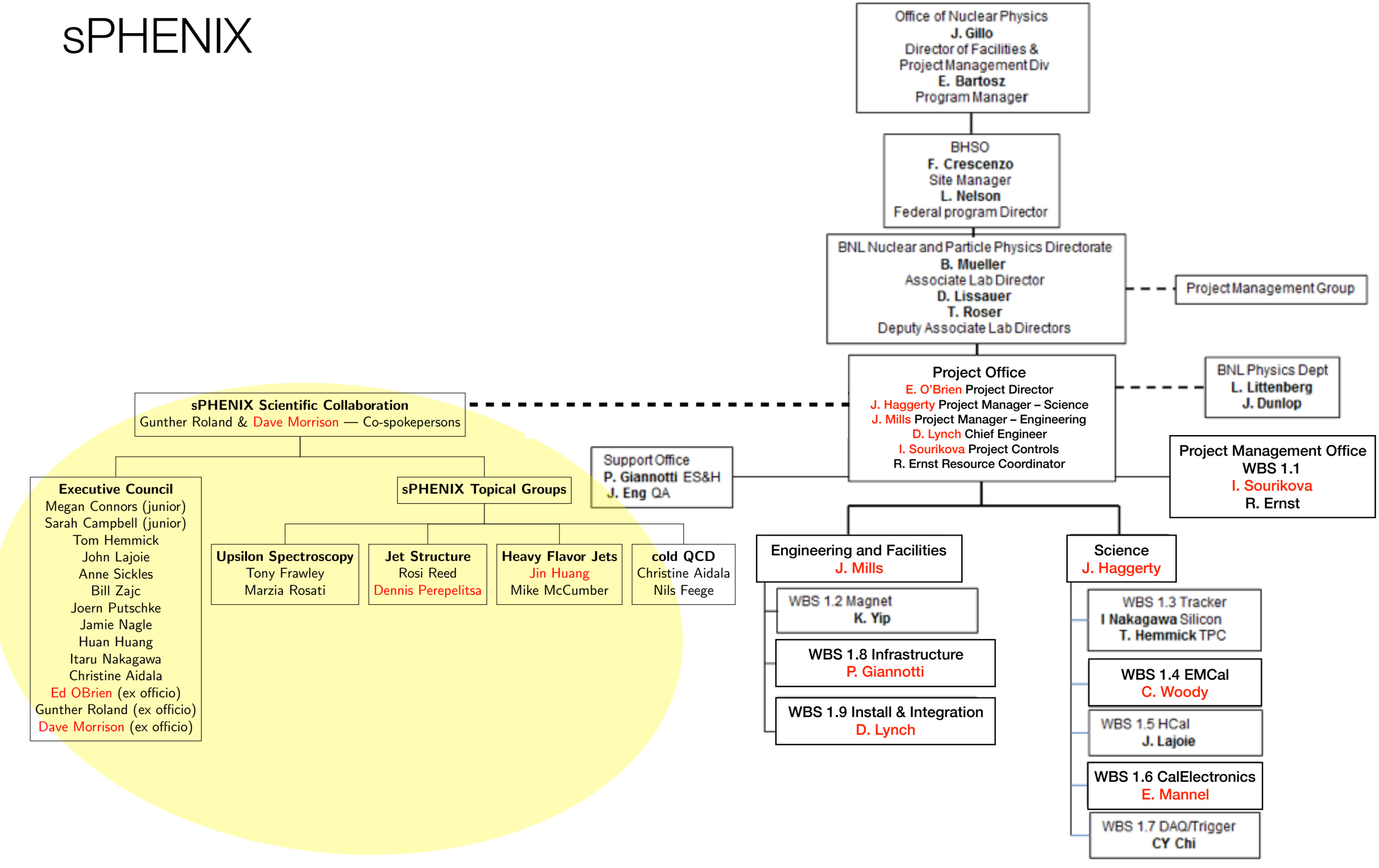
PHENIX Operations
Mickey Chiu — Director
John Haggerty — Deputy Director
Don Lynch — Chief Engineer

Detector Council
Toru Sugitate — BBC
Cheng-Yi Chi — DAQ
Achim Franz (moved to Dept. ESSH) — Data Production
Victor Riabov — DC
Justin Frantz — EMCal PbGl
Edouard Kistenev — EMCal PbSc
Melynda Brooks — FVTX
Itzhak Tserruya — HBD
John Lajoie — LVL1
Achim Franz (moved to Dept. ESSH) — Magnets
Ken Read — MuID
Mike Leitch — MuTr
Matthias Grosse-Perdekamp — MuTrigger
Vicki Greene — PC
Hideki Hamagaki — RICH
Chris Pinkenburg — Simulations
Yasuo Miake — TOFE/Aerogel
Julia Velkovska — TOFW
Yasuyuki Akiba — VTX
John Haggerty — ZDC

Run Coordinator
Denis Jouan

Trigger Coordinator
Sasha Bazilevsky
Spin Coordinator
Ralf Seidl
DAQ Coordinator
Martin Purschke

sPHENIX


Office of Nuclear Physics
J. Gillo
Director of Facilities & Project Management Div
E. Bartosz
Program Manager
BHSO
F. Crescenzo
Site Manager
L. Nelson
Federal program Director
BNL Nuclear and Particle Physics Directorate
B. Mueller
Associate Lab Director
D. Lissauer
T. Roser
Deputy Associate Lab Directors
Project Management Group
Project Office
E. O'Brien Project Director
J. Haggerty Project Manager – Science
J. Mills Project Manager – Engineering
D. Lynch Chief Engineer
I. Sourikova Project Controls
R. Ernst Resource Coordinator
BNL Physics Dept
L. Littenberg
J. Dunlop
Project Management Office
WBS 1.1
I. Sourikova
R. Ernst
Support Office
P. Giannotti ES&H
J. Eng QA
sPHENIX Scientific Collaboration
Gunther Roland & Dave Morrison — Co-spokepersons
Executive Council
Megan Connors (junior)
Sarah Campbell (junior)
Tom Hemmick
John Lajoie
Anne Sickles
Bill Zajc
Joern Putschke
Jamie Nagle
Huan Huang
Itaru Nakagawa
Christine Aidala
Ed OBrien (ex officio)
Gunther Roland (ex officio)
Dave Morrison (ex officio)
sPHENIX Topical Groups
Upsilon Spectroscopy
Tony Frawley
Marzia Rosati
Jet Structure
Rosi Reed
Dennis Perepelitsa
Heavy Flavor Jets
Jin Huang
Mike McCumber
cold QCD
Christine Aidala
Nils Feege
Engineering and Facilities
J. Mills
WBS 1.2 Magnet
K. Yip
WBS 1.8 Infrastructure
P. Giannotti
WBS 1.9 Install & Integration
D. Lynch
Science
J. Haggerty
WBS 1.3 Tracker
I Nakagawa Silicon
T. Hemmick TPC
WBS 1.4 EMCal
C. Woody
WBS 1.5 HCal
J. Lajoie
WBS 1.6 CalElectronics
E. Mannel
WBS 1.7 DAQ/Trigger
CY Chi

PHENIX Operations

BNL/PHENIX group has provided key support to maintain and operate detector, and to build and improve equipment

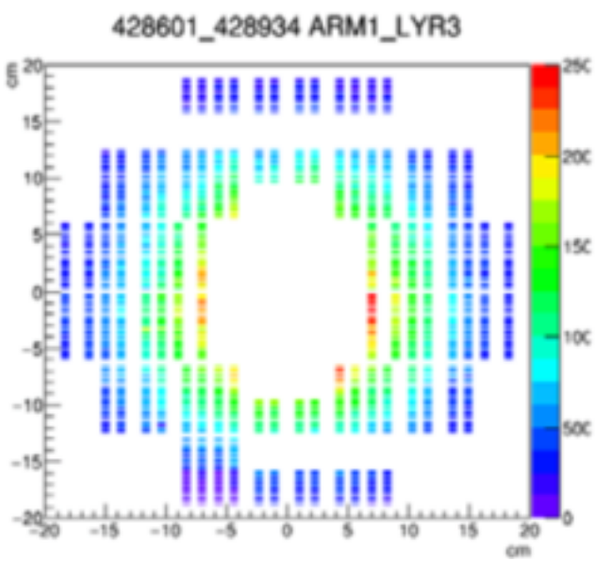
red = DC Member/Subsystem Leader

DAQ – Martin Purschke, Ed Desmond, John Haggerty, Mickey Chiu
ONLCAL/ONLMON/RCF Liaison – Chris Pinkenburg
ZDC – John Haggerty
MPC – Mickey Chiu
MPC-EX – Edward Kistenev, Andrey Sukhanov, Steve Boose
EMC – Edouard Kistenev, Sean Stoll, Jeff Mitchell
RICH – Takao Sakaguchi
VTXS/VTXP – Rachid Nouicer, Eric Mannel, Mike Lenz, Rob Pisani
FVTX – Jin Huang
HV – Martin Purschke, Sal Polizzo
LV – Steve Boose, Sal Polizzo, John Haggerty
Safety Systems – Paul Giannoti, Frank Toldo
Gas Systems – Carter Biggs, Rob Pisani, John Tradeski
Slow Controls – Steve Boose, John Haggerty, Frank Toldo
Magnets – Achim Franz
Infrastructure Support – Carter Biggs, Don Lynch, Jimmy Labounty, John Tradeski

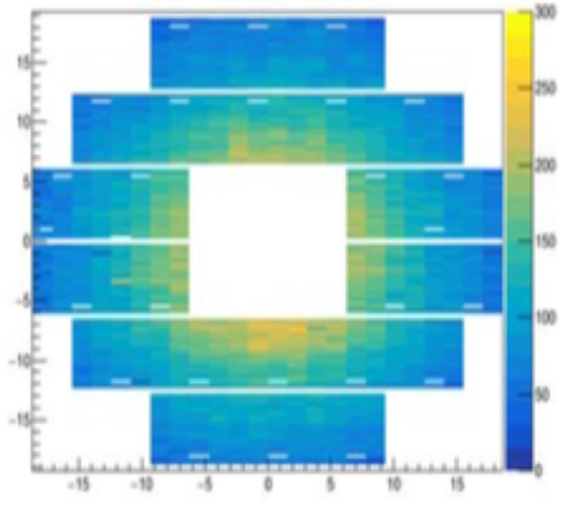
PHENIX Operations - maintain/improve detectors

1. MPC-EX W-Si preshower for forward direct γ
   - FEM+Carrier Boards: A. Sukhanov (moved to C-AD)
   - HV/LV Distribution Boards: S. Boose
   - DAQ Integration: E. Desmond, M. Purschke
   - Mechanical Design: D. Lynch, R. Ruggiero
   - Installation: J. Labounty, C. Biggs, F. Toldo
   - Firmware improvements Run15 to Run16 ⇒ 95% live

Run15



Run16



2. VTX/FVTX cooling system improvements for Run15
   - Run14 static discharge and condensation issues
   - No issues in cooling system for Run15/16

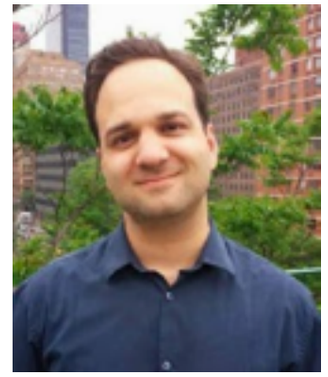
3. Repair of MPC and VTX damaged by beam dumps in Run15 p+Au
   - Protection diodes added to MPC
   - VTX-S ladders reconfigured to maximize live area

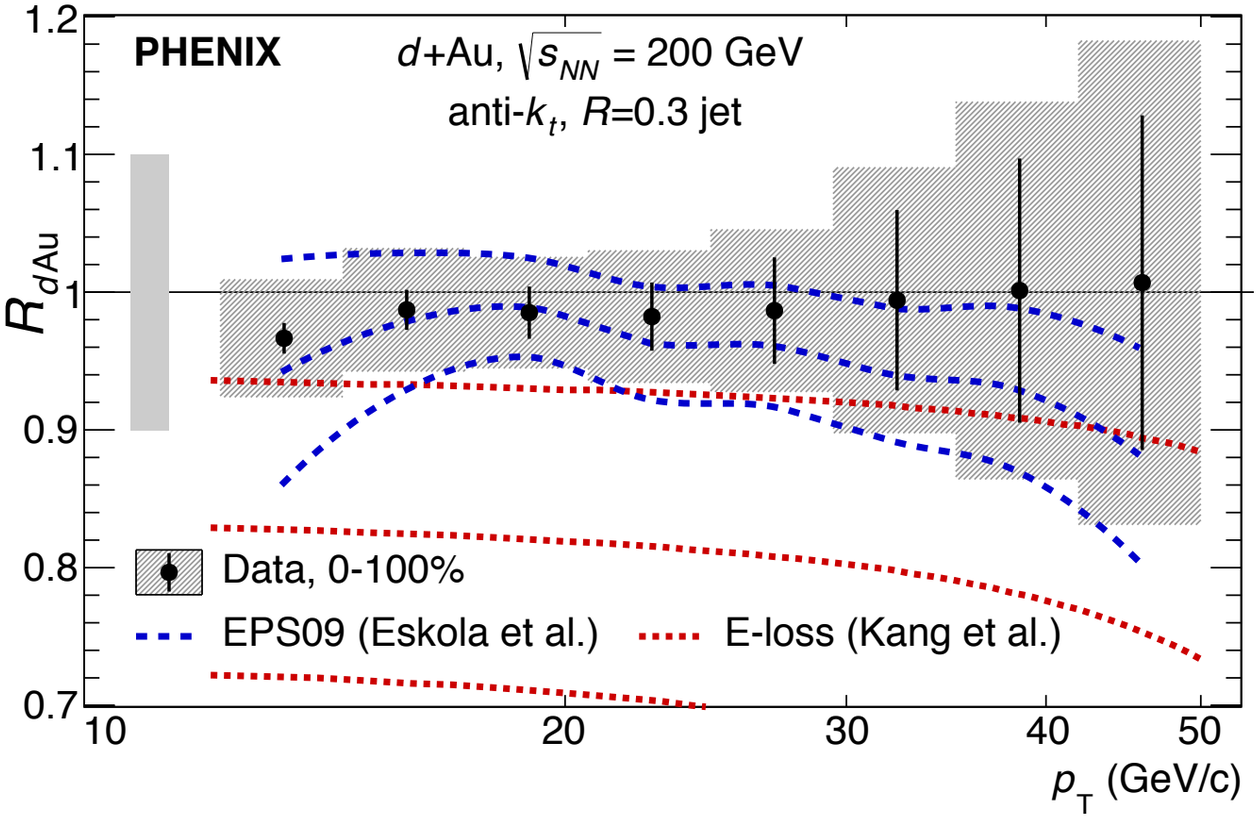
Scientific productivity since 2014 S&T review

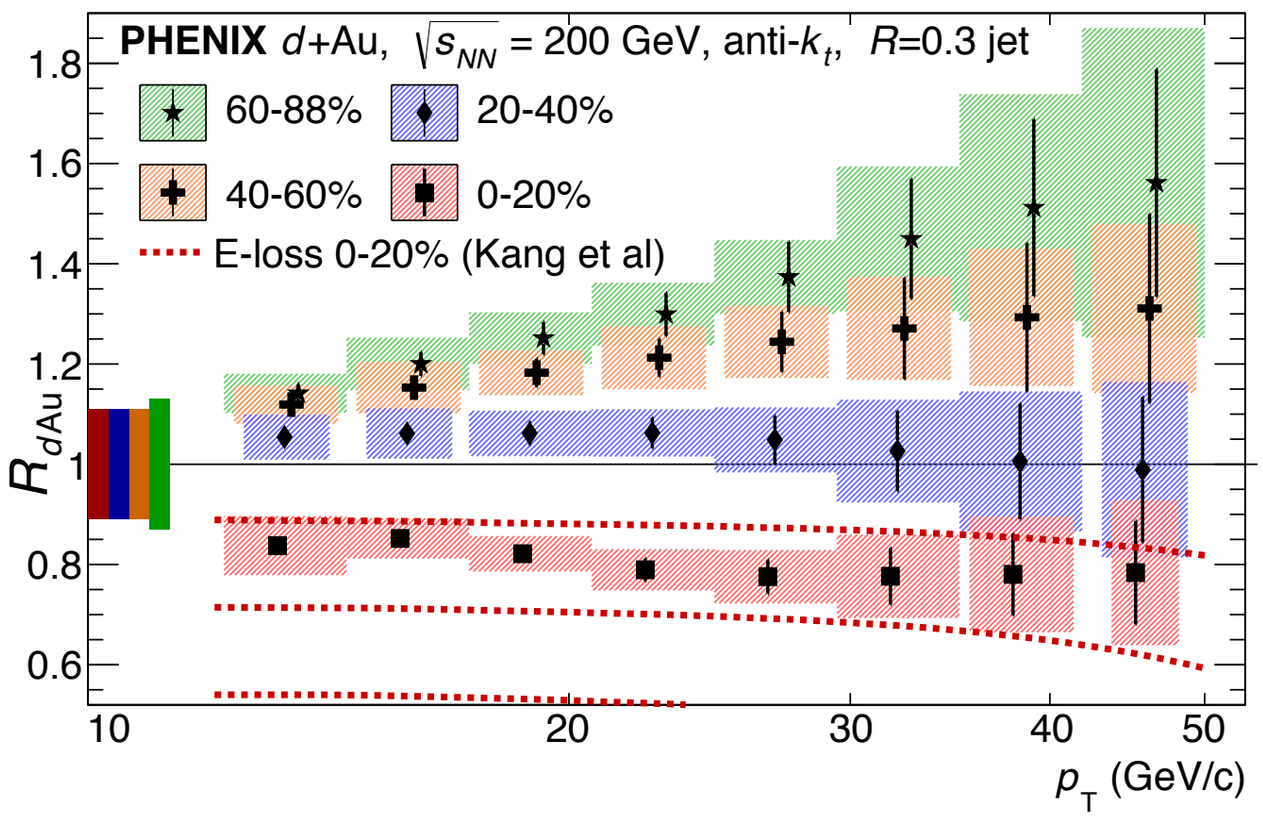
- 5 IAC spots
- 8 LOC spots (including conveners at conferences)
- 45 invited seminars and talks
- Primary authors or on internal review committees or editors on 59 refereed papers (PHENIX, ATLAS, sPHENIX, few author, review and white papers)

Jet production in *d*+Au

Dennis Perepelitsa
a primary author
Goldhaber Fellow
BNL ⇒ Colorado

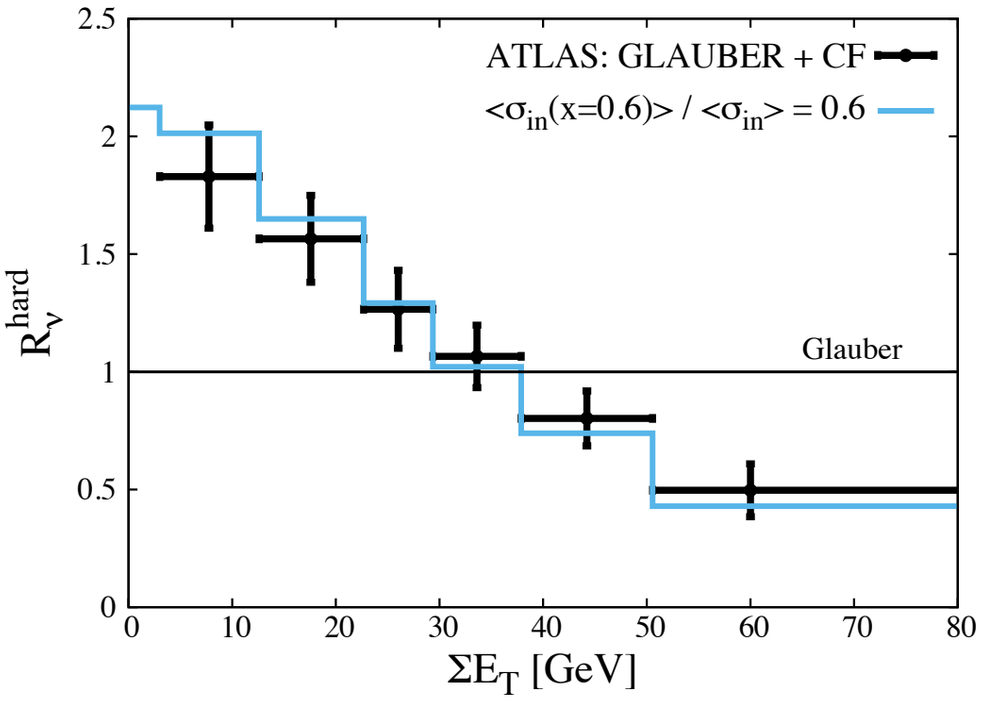


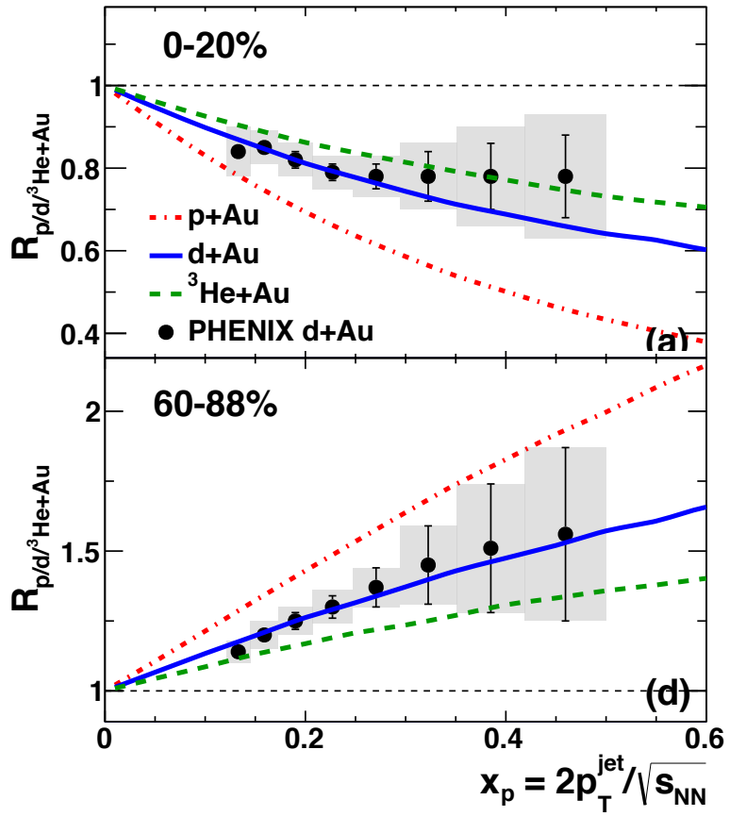




- PHENIX Collaboration, Centrality-dependent modification of jet-production rates in deuteron-gold collisions at $\sqrt{s_{NN}}$ = 200 GeV, Phys. Rev. Lett. 116 (2016)122301
- Measurement of nPDF / cold-nuclear matter effects over large kinematic range at RHIC
- First measured jet spectrum in non-p+p collision system at RHIC – finalizes QM'12 result; observation of qualitatively similar effects to p+Pb data at LHC

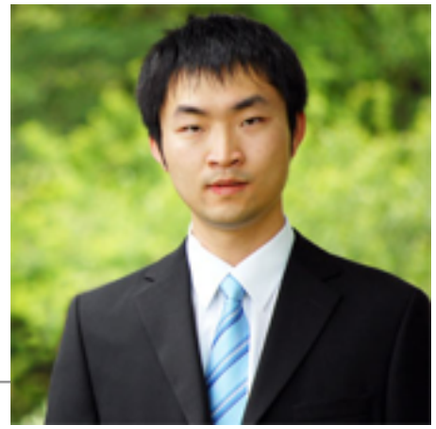
Possible *x*-dependent proton size fluctuations





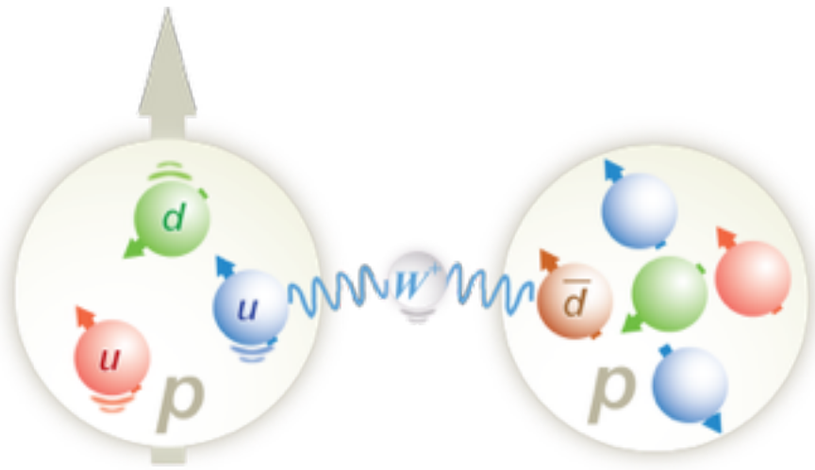
- Alvioli, Cole, Frankfurt, Perepelitsa, Strikman, Evidence for x-dependent proton color fluctuations in pA collisions at the CERN Large Hadron Collider, Phys. Rev. C93 (2016) 011902
  - ➡ explanation of p+Pb effects at the LHC as arising from “shrinking” or “weakly interacting” proton, with quantitative comparison of model to data
- McGlinchey, Nagle, Perepelitsa, Consequences of high-x proton size fluctuations in small collision systems at RHIC, nucl-th/1603.06607, Accepted by Phys. Rev. C
  - ➡ proposal to test shrinking proton picture with p/d/^{3}He+Au data at RHIC

Jin Huang

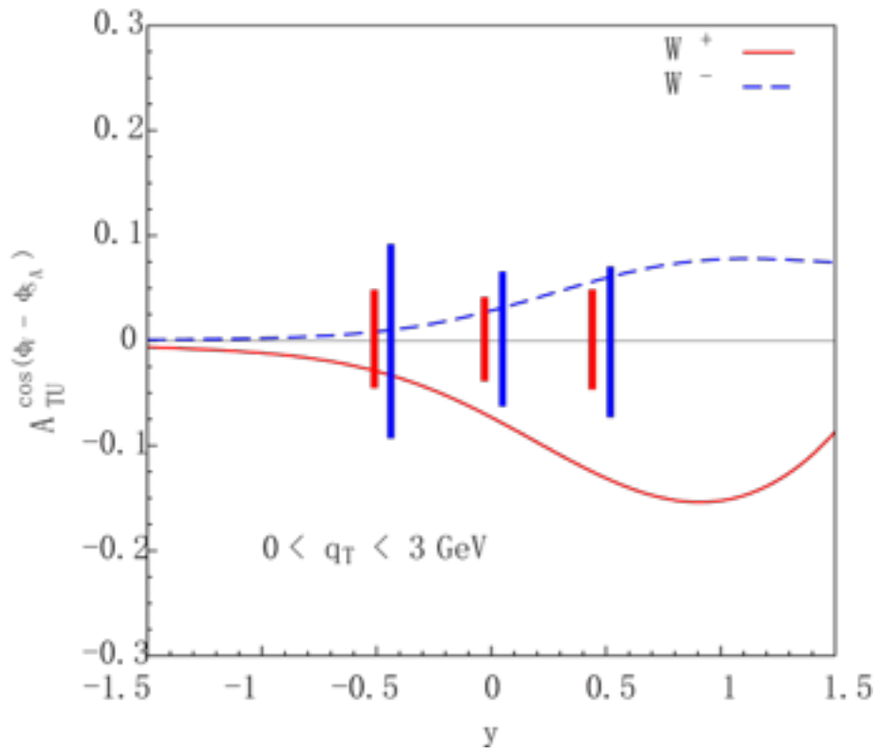


Huang, Kang, Vitev, Xing, PRD 93 (2016)

Within TMD factorization formalism, presents the cross sections for weak boson production in polarized pp collisions. And estimated the spin asymmetries at the top RHIC energy.



- **Curve:**
  Huang, Kang, Vitev, Xing, PRD 93 (2016)
- **Points: Jin's naïve expectation of STAR Run17 projection based on Sivers A_N projection in RHIC Cold QCD plan**



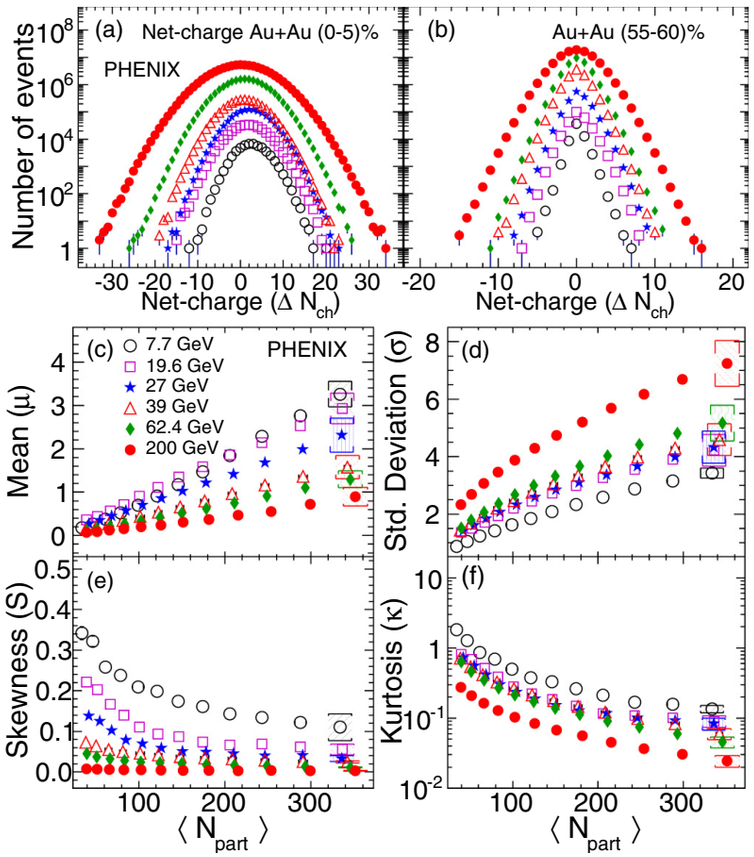
$p^{\uparrow}p \rightarrow W + X \rightarrow (e+\nu)+X$, transversely polarized p+p collision @ $\sqrt{s} = 510$ GeV

Unique opportunity of probe transversal helicity g_{1T} via parity violating single transverse spin asymmetry. With Sivers measurements, comprehensively tests universality properties of TMDs, constrains the TMD evolution effects

g_{1T} = 

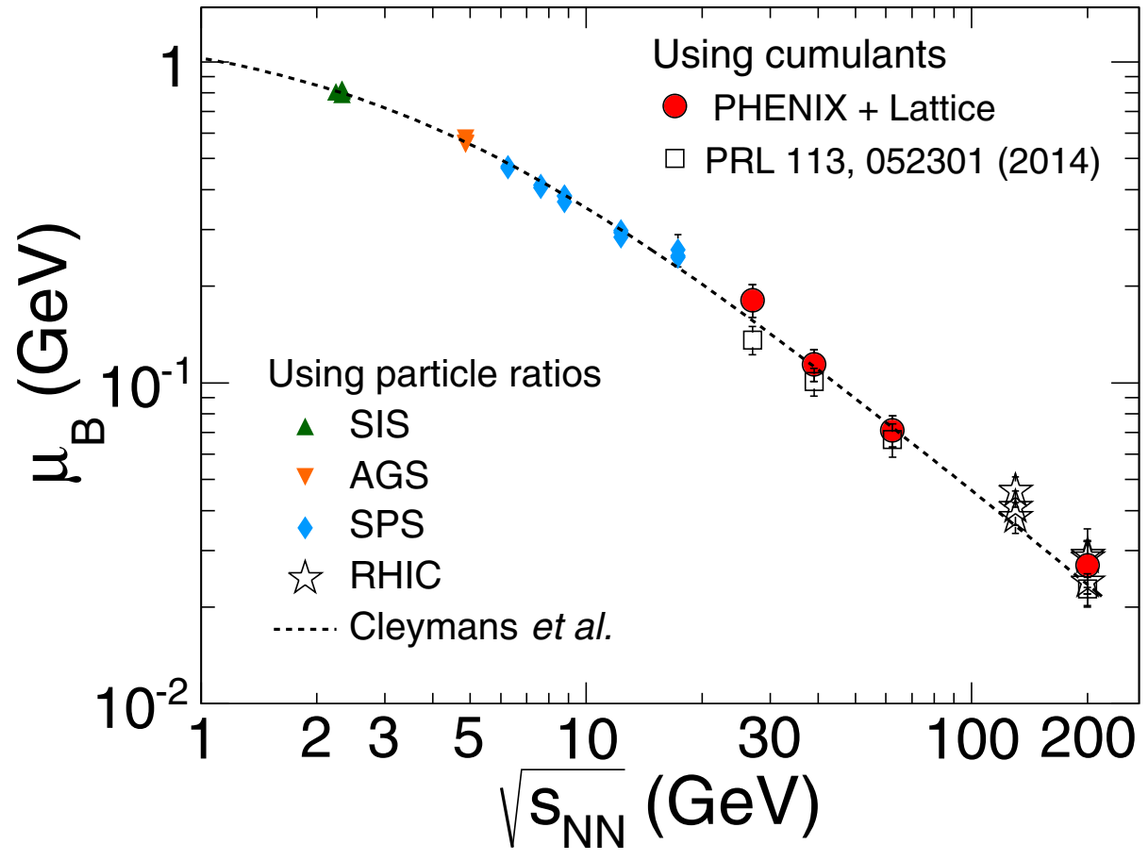
Net charge fluctuations

"Measurement of higher cumulants of net-charge multiplicity distributions in Au+Au collisions at $\sqrt{s_{NN}}$ = 7.7–200 GeV", Phys. Rev. C 93, 011901(R) 2016 (primary authors include Jeff Mitchell (moved to EBNN), Mike Tannenbaum)



uncorrected net charge distributions

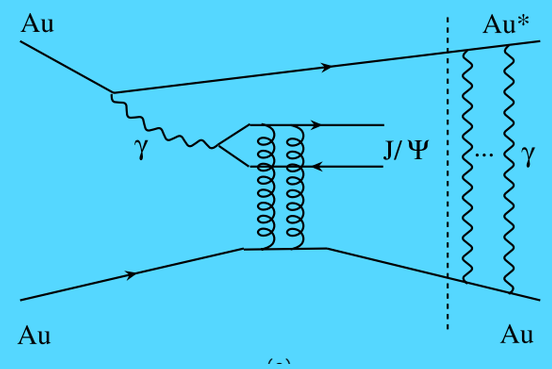
products and ratios of cumulants of fully corrected distributions – dependence on volume drops out



with input from LQCD, determine μ_B and T_f vs $\sqrt{s_{NN}}$ with small uncertainties

Ultra-peripheral physics in Pb+Pb with ATLAS

Peter Steinberg



Photon-pomeron:
production of vector mesons (sensitivity to nPDF)

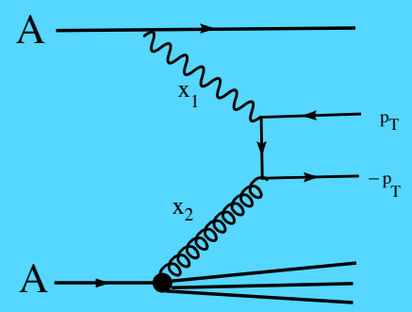
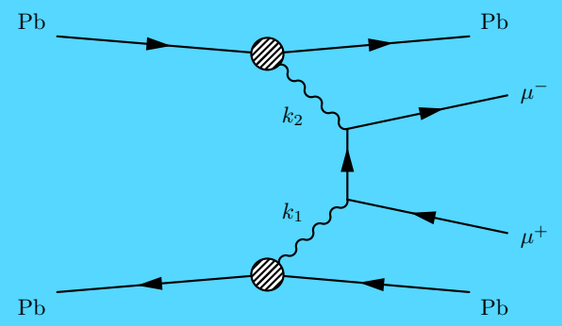
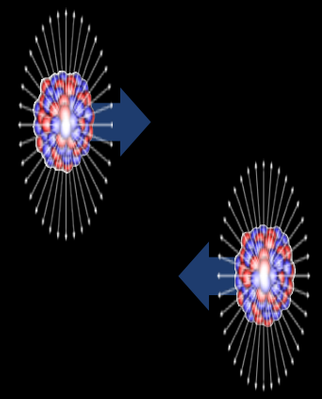


Photo-nuclear:
jet photoproduction (probe nPDF directly)

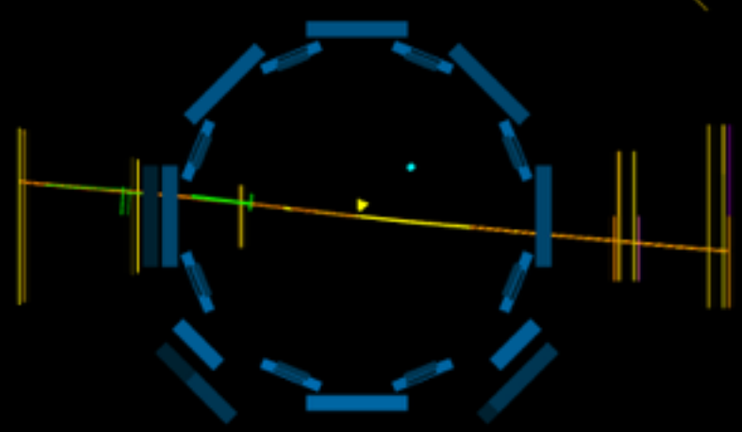


Photon-photon:
dilepton production (& other exclusive states)

Strong EM fields, highly contracted: source quasi-real photons to probe nucleus (& nucleon in p+Pb).

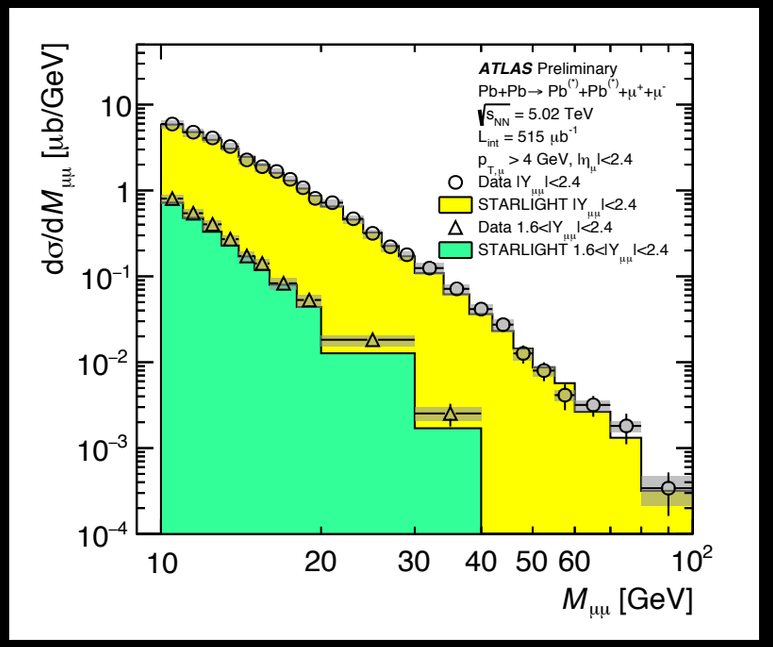


Access to some EIC physics in the pre-EIC era?



exclusive dimuon event in ATLAS:
$M_{\mu\mu}$=173 GeV

STARLIGHT MC implements collisions of Weisacker-Williams quasi-real photons + QED μ± production



sPHENIX physics

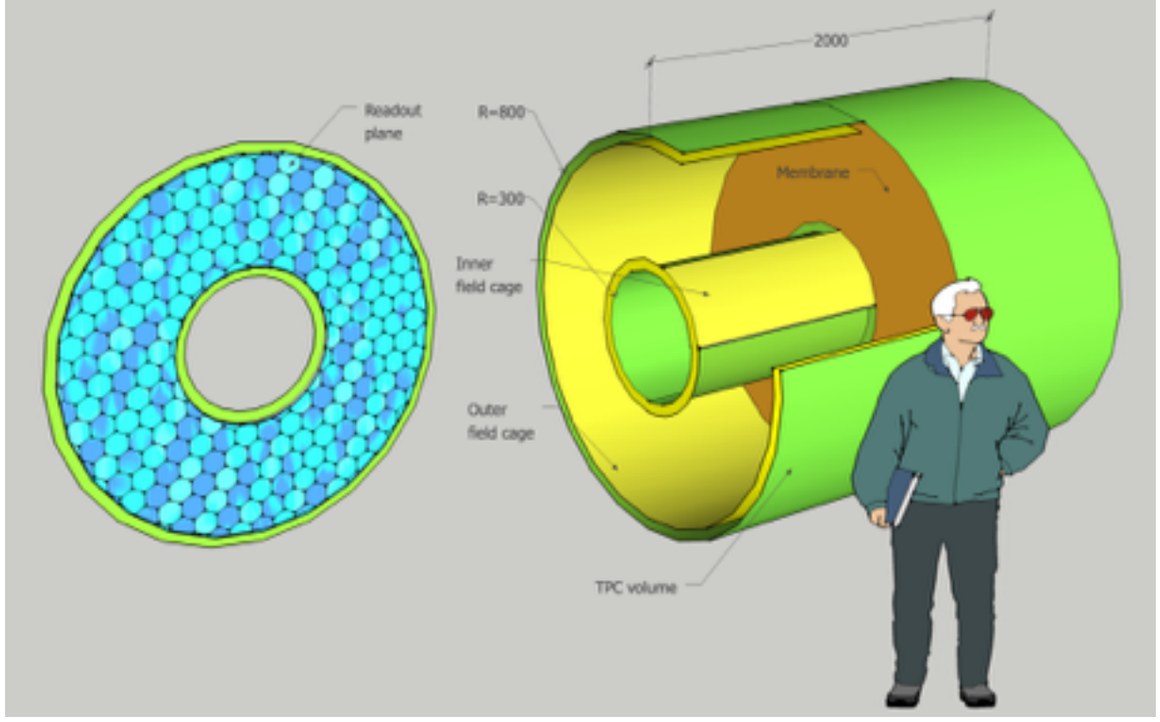
- sPHENIX science case (Morrison, Huang, Perepelitsa)
  - Jet b-tagging studies, now with full GEANT4 detector simulations (Perepelitsa)
  - EMCal simulations – studies of 1D vs 2D projectivity and relevance to Upsilons (Huang)
- Co-conveners of sPHENIX topical groups (Huang, Perepelitsa)
- Computational framework, code development, simulations (Pinkenburg, Purschke, Huang)

Tracking R&D

sPHENIX requirements Upsilons with Δm/m ~ 100 MeV/c; DCA < 100 μm; pattern recognition in central HI (and in jet cores)

Time projection chamber for sPHENIX tracking

- Fast, compact TPC with GEM readout
- Potentially reusable for eRHIC detector



SBU+Woody, Azmoun, Sakaguchi

Investigation of possible intermediate silicon strip tracker: Hamamatsu sensors being tested

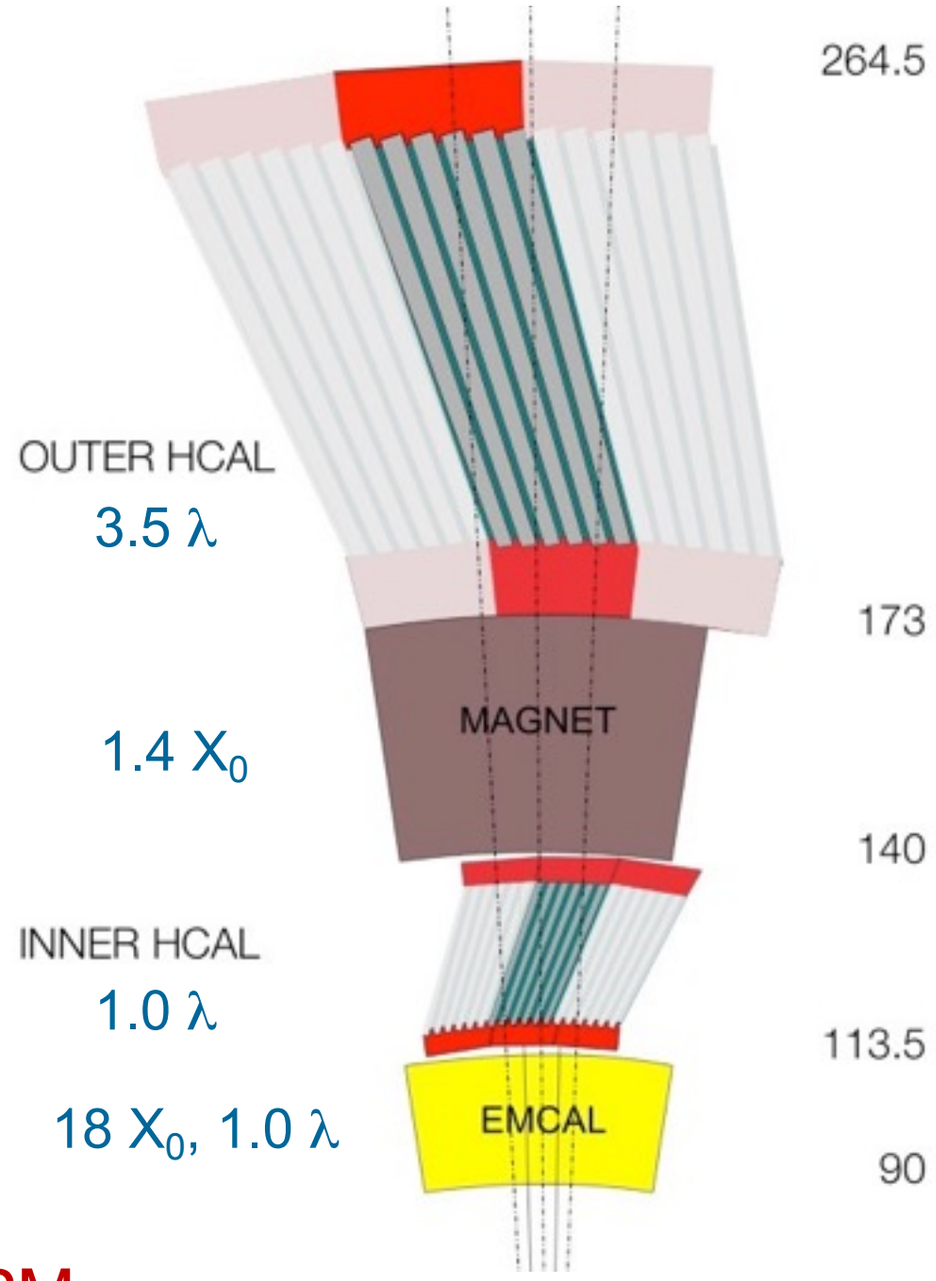
RIKEN+Nouicer

sPHENIX Calorimeters

azimuthal slice of sPHENIX

HCAL – Steel plates + scintillating tiles
with WLS fiber readout

EMCAL – Tungsten SciFi SPACAL
– based on UCLA design, with
extensions to 2D projectivity and with
large scale production innovations



Both EMCAL and HCAL read out with SiPMs

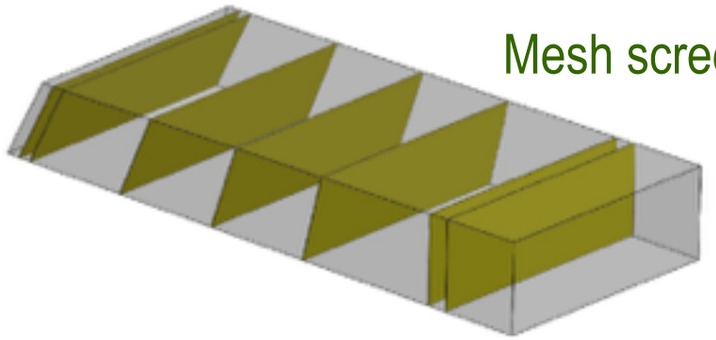
technicians, Kistenev, Haggerty

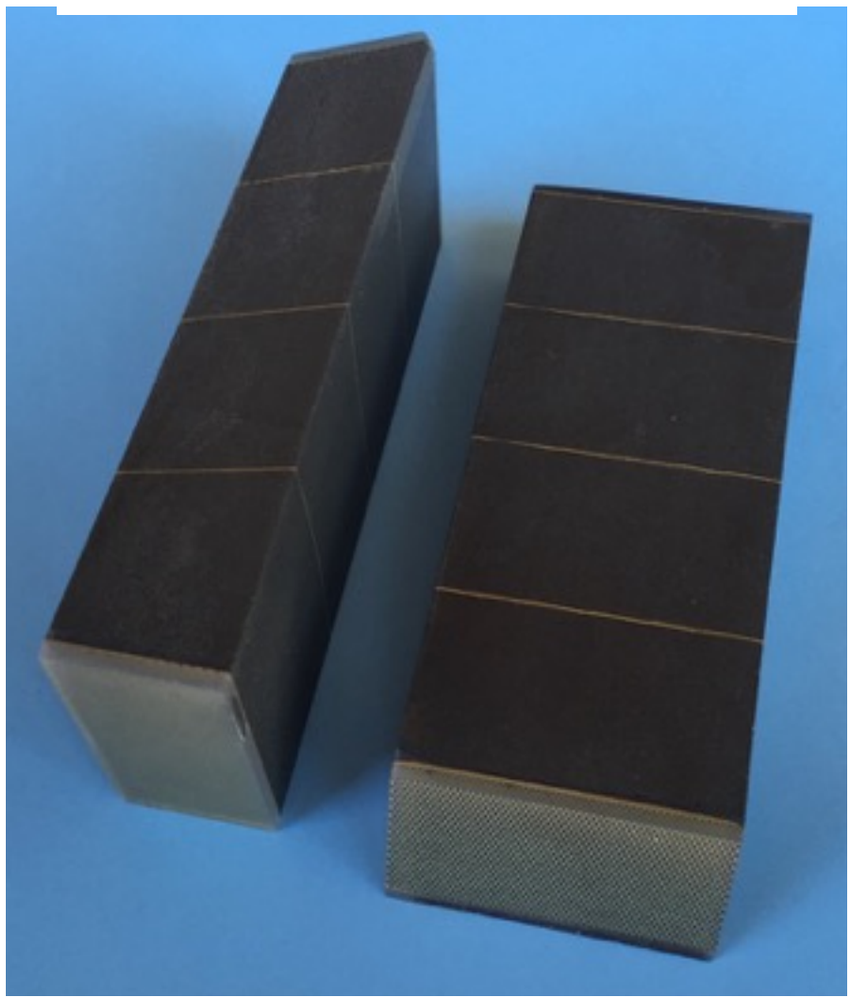
EMCAL + HCAL ~ 5.5 λ

W/SciFi Modules

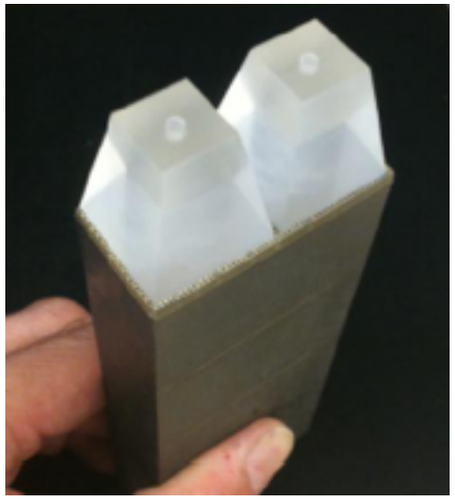
UIUC+Woody, Stoll

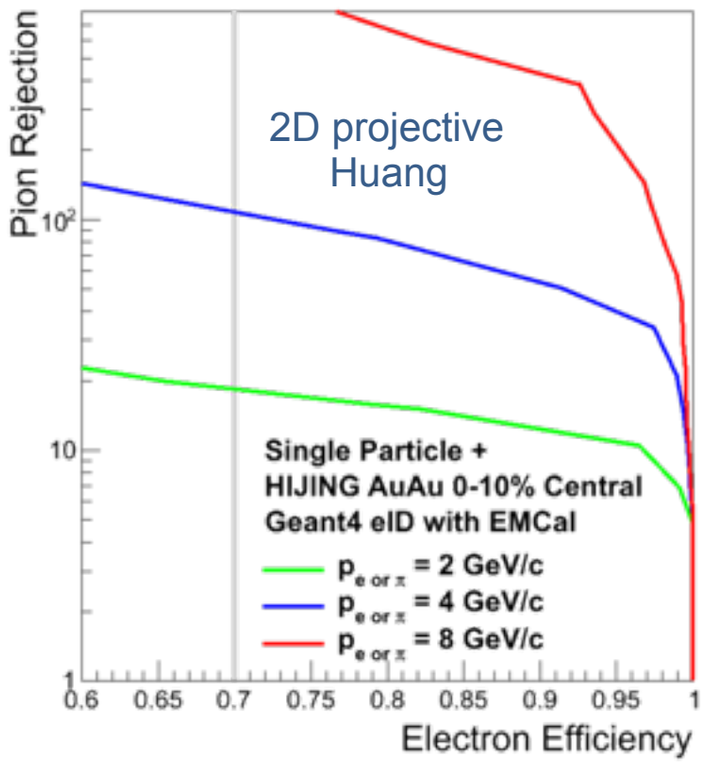
1D Projective



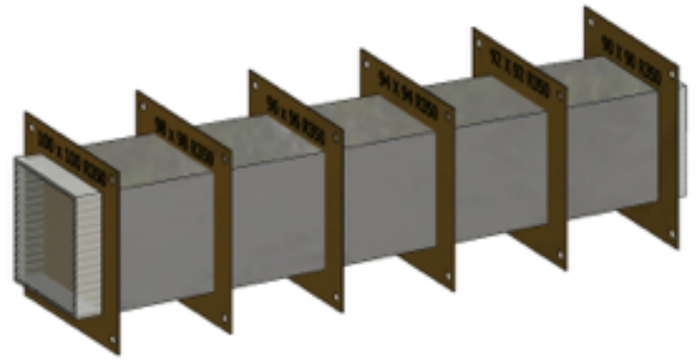


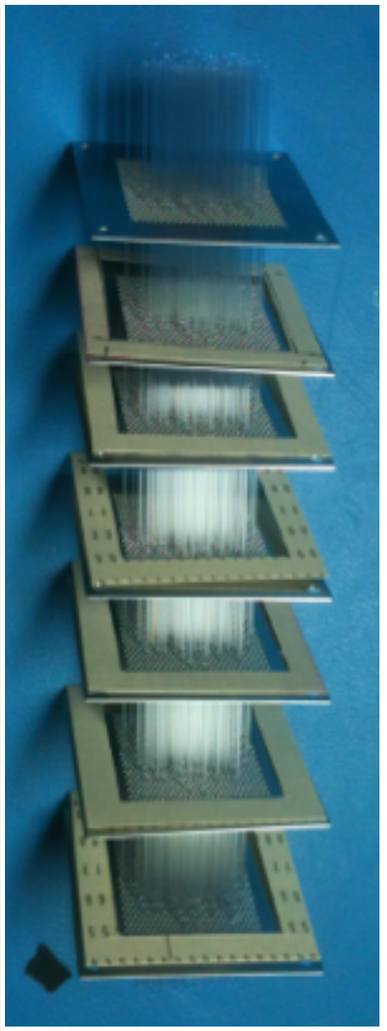
Light guides and SiPMs are attached to module ends to form towers



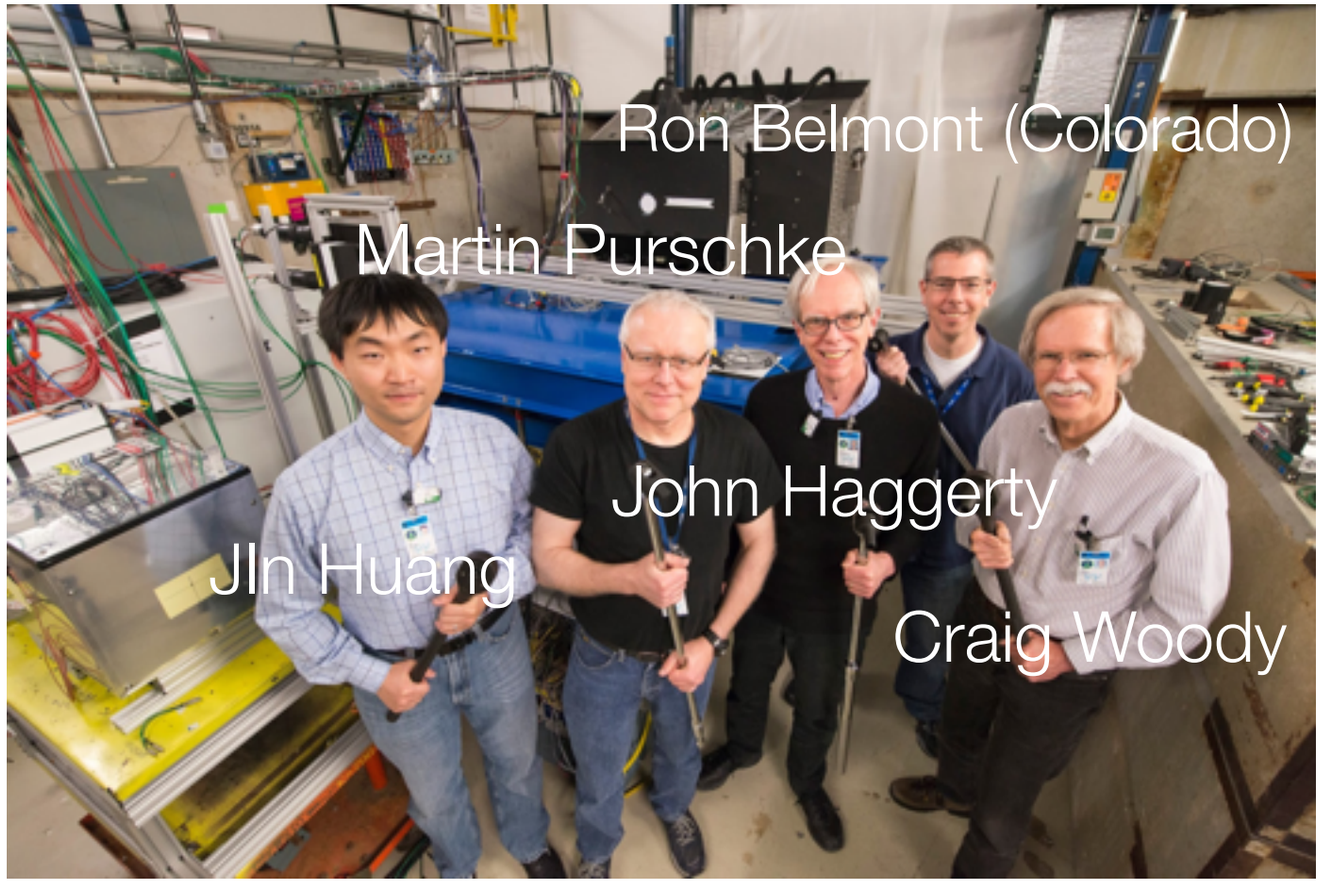


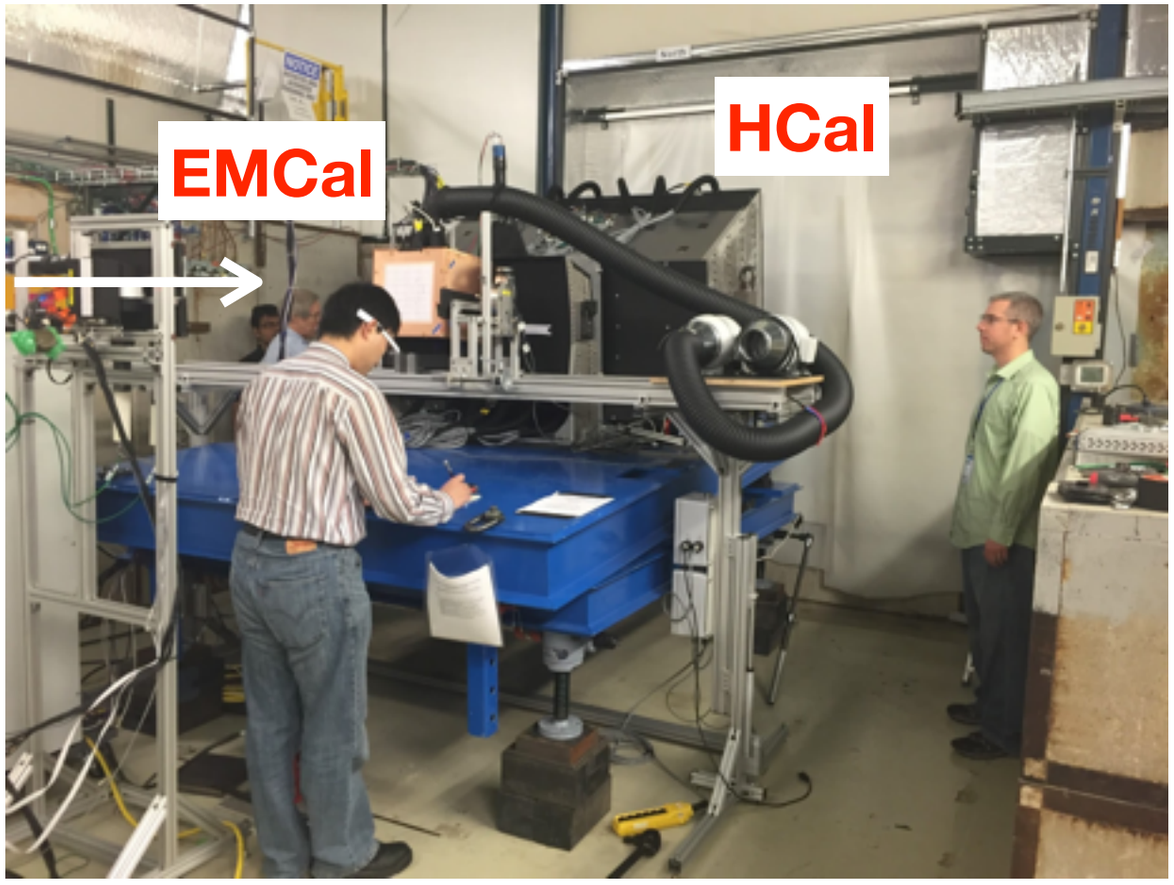
2D Projective





Proving R&D in test beam

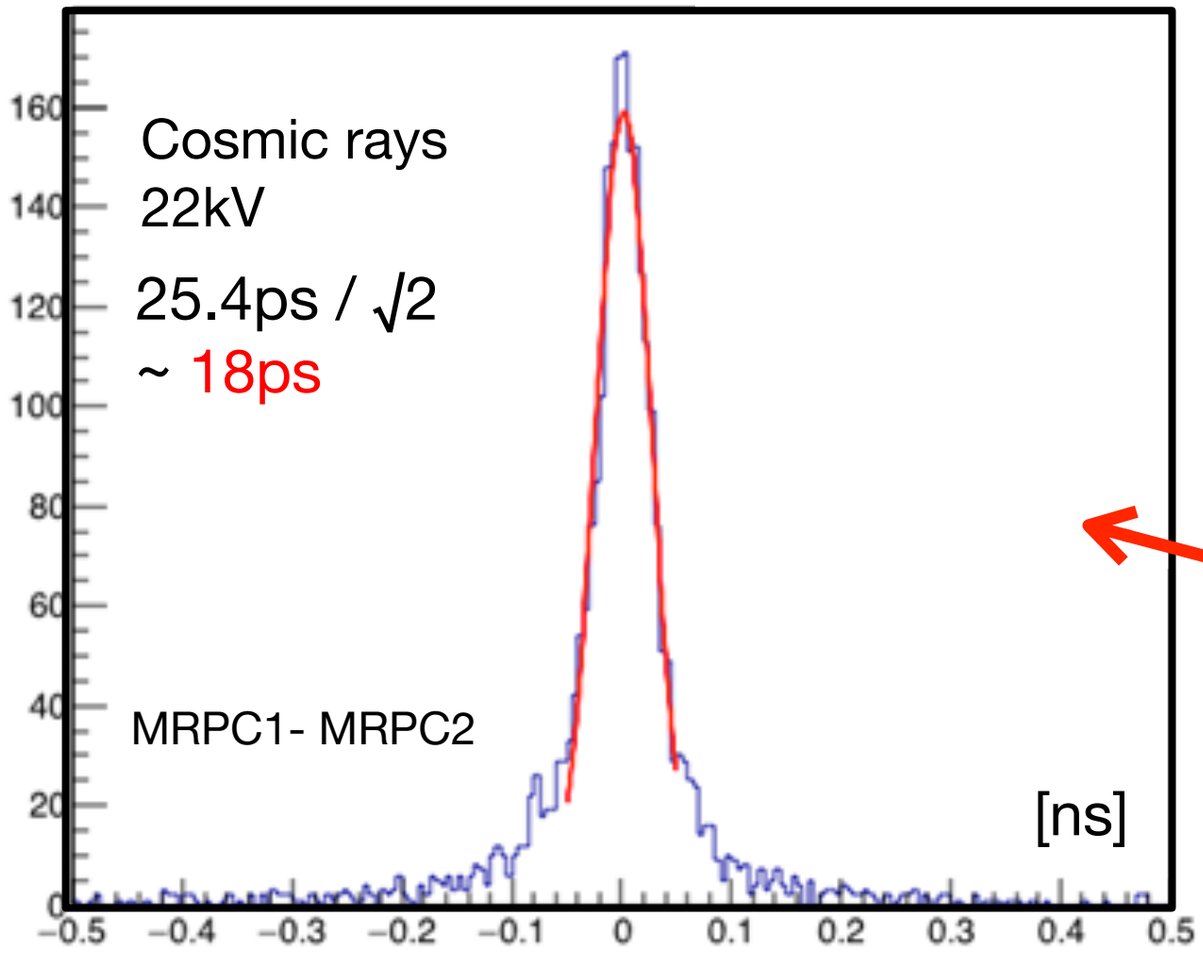


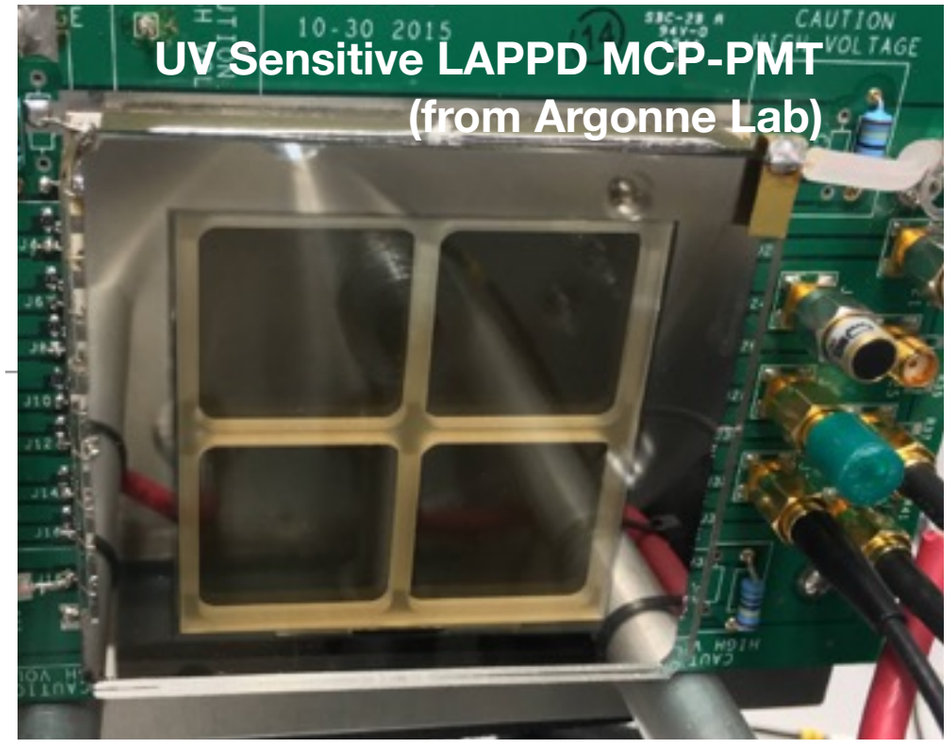


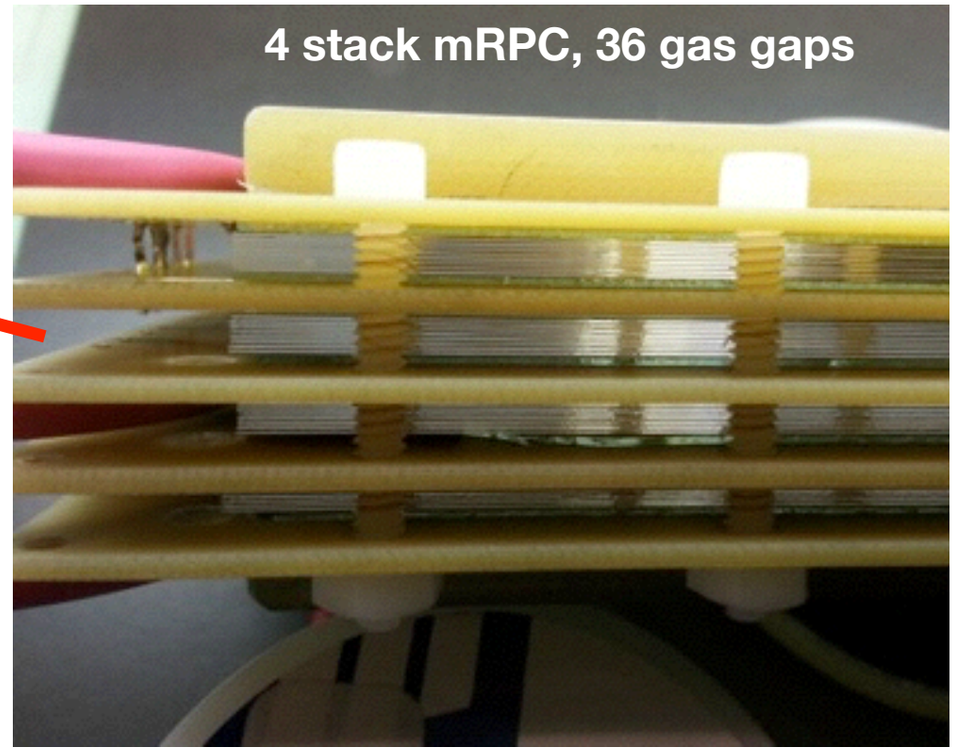
sPHENIX detector development coordinated with the collaboration most notably in beam tests at Fermilab and 2014 and 2016 involving over 30 collaborators from BNL and collaborating institutions

High Performance TOF R&D

M. Chiu, A. Sukhanov (now at C-AD)







Investigating both mRPC and MCP-PMT technologies
Collaboration with UIUC, Howard, and ACU (M. Perdekamp and M. Chiu are co-PI's)
Funded by M. Chiu PECASE, EIC Generic R&D, and UIUC NSF Grant
Hosts of 4 ACU and 4 Howard undergraduate students in summer 2015 and 2016
Achieved ~20 ps with thin glass mRPC
Building sPHENIX compatible DRS4 readout board over next year

longtime PHENIX Summer Sunday lead: Achim Franz
(moved to Physics Dep't. ESSH)

Recent PHENIX public outreach

Setup by BNL/PHENIX technicians

Cloud chambers
Detector components
VR headsets

Summer Sunday 2016:
1400 visitors

By Marissa Shieh | July 21, 2016 PRINT

Pinkenburg and the GearHeadz

Brookhaven physicist spends spare time coaching kids' robotics team

BNL article about Chris Pinkenburg coaching robotics team at local school

Achim Franz: one-hour science show for a girls summer camp, at ICHEP 2016

Engaging students in research

- PHENIX operations – shifts, data monitoring, analysis – all involve students and postdocs

- Wide array of ongoing R&D involves students working with members of the PHENIX group. Some examples from this summer include EMCal mechanical prototyping using 3D printing, cosmic ray test stand for fast TOF

  - Abilene Christian University (Rusty Towell and students)

  - Howard University (Marcus Alfred and students)

  - Stony Brook University (Spencer Locks (mech. engineering))

- Tours (~30/year) for visitors, many student groups

Summary

- Group continues to be very successful with key responsibilities and activities: PHENIX operations and collaboration support, PHENIX and ATLAS HI analysis, R&D, planning for future scientific directions

- Scientific staff recently reduced by five FTEs, technical staff reduced by three FTEs; Goldhaber postdoc Perepelitsa now Asst. Prof. at Colorado

- Will rapidly ramp-down PHENIX operations effort towards ~1.5 FTE

- Anticipating sPHENIX, a pivot in direction of group effort – generic R&D, project management, support of test beam, hosting of sPHENIX collaboration. Aim to build and maintain “critical mass” of intellectual strength on key sPHENIX science – obvious target is jet physics

- Exciting, but very challenging period of transition. Maintaining group’s scientific strength, to recruit and retain needed personnel, will require continued support from Laboratory to hire postdocs, junior staff, targeted hires.